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A new tissue-grade organism 1.5 billion years old from Montana

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Abstract.—"Problematic bedding-plane markings" that resemble a "string of beads" from the Appekunny Formation in the eastern part of Glacier National Park Montana are described as *Horodyskia moniliformis,* a new genus and new species. The matrix shows laminations at an exceptionally fine scale, and, during life these aquatic organisms may have been intermittently lightly covered by wind-blown quartz dust. Growth stages are present: tiny, elongate, benthonic threads develop swellings; swellings grow upward; more robust forms have wide short cones. At all growth stages, the spacing of the cones is approximately proportionally to the diameter of the enlarging cones. To account for this phenomenon, presumably cones intermediate in position along the thread episodically ceased growth. Thus, the organism exhibits a form of colonial growth.

The late R. J. Horodyski (1982) described material from Glacier National Park (GNP) as "problematic bedding-plane markings." This material is best seen in the field as light spots on a dark matrix, and are informally called "string of beads." Similar-appearing material has been illustrated and discussed, but not named, from Western Australia (Grey and Williams 1990).

About 2000 meters of strata are exposed in the eastern and central part of GNP (Fedonkin et al. 1994). The fossils of interest are limited to the lower few meters of the 700 meter thick Appekunny Formation. The aquatic Altyn Formation, a stromatolite-bearing limestone at the base of the section, is cut off below by a thrust fault. It is overlain by the clastic Appekunny and Grinnell Formations. The Appekunny is variegated and the Grinnell is distinctly red. The Siyah Formation, another aquatic stromatolitic limestone, is next in sequence and is followed by the Snowslip Formation and the Shepard Formation, both clastic, the Shepard being cut off at its top by another thrust fault. The Pursell Lava lies between the Snowslip and the Shepard and U/Pb dates for that unit range from 1508 to 1845 million years (Alenikoff et al. 1996).

The fossils are known from three adjacent localities (Fedonkin et al. 1994), possibly within the same narrow stratigraphic level. D. W. Winston (in litt.) notes that these beds are unique to the Belt Supergroup in being aquatic, rather than terrestrial, red beds. This lower portion of the Appekunny is further remarkable as an exceptionally fine siltite having several microlaminae per mm. In some beds the laminae are gently inclined to form very low hummocky cross-bedding. Higher in this formation, the hummocks are larger, almost all of sequence is of more red beds, and mud cracks and a few shale clasts are present. We interpret the lower fossiliferous beds as quiet water deposits, the sediment forming them being derived from air-borne quartz dust.

Systematic Paleontology

Kingdom, Phylum, and Class Incertae Sedis

Horodyskia, new genus

Type species.—*Horodyskia moniliformis*, new species.

Diagnosis.—Presumed colonial organisms of small, vertically oriented, short wide cones, hemispherical on the upper surface, growing from a horizontal tube.

Horodyskia moniliformis, new species

Description.—A series of spherical bodies growing from a thin horizontal stolon of variable length and variable orientation relative to troughs and ridges of substrate. Diameter of spherical bodies and spacing between them nearly coequal. As upward growth begins, number of bodies per unit length of string decreases. With further vertical growth, the bodies elongate into wide cones, but remain essentially proportionally spaced. Regardless of the size of individuals, spacing between them remains approximately proportional to diameter of cones and number of cones per unit length of string decreases with increase of cone diameter.

Etymology.—Named in honor of the contributions made by R. J. Horodyski to Precambrian paleontology. The trivial name refers to necklace or string of beads appearance.

Type specimens and related material.—Holotype, United States National Museum (USNM) 508100 (Fig. 1); paratypes USNM 508101–508131, (not figured herein). The type locality is on the Running Wolf Mountain, at approximately the 1700 m contour; this mountain is just north of Two Medicine campground, near the east boundary of GNP, Montana. The primary types are supplemented by about 275 additional slabs; many of these contain more than one string. In addition, ten days were spent in the field examining specimens on the outcrop and collecting.

Systematic position.—The classic divisions of plant or animal cannot be readily applied to some organisms in the fossil record; our material is too complex to fit within the Protista. If a choice must be made between those two entities, we would place *Horodyskia* as an animal. As will be discussed below, the beads were apparently episodically covered by exceedingly fine sediment and this would tend to inhibit photosynthesis as a possible food source. That does not prove a connection to Animalia, but is suggestive.

Preservation.—On all of the strings examined, only two modes of preservation have been noted. Either the individual beads are replaced by silica or they lack an integument and are represented by internal fillings. Specimens are preserved in these two modes on both bedding plane and sole surfaces of slabs. No organic matter has been observed on any specimen. Thus, the prospects for studying any so-called biologic signals from carbon isotopes is remote, even though, the matrix is little metamorphosed, relative to correlative beds on the western side of GNP.

The slab bearing the holotype (Fig. 1) was selected from a darker colored bed, in part because this may provide the opportunity for geochemical investigations in the future when new techniques might be developed. The string of beads to the upper left of the scale is the holotype and to the upper left of the last bead of the holotype are four smaller beads of another string. In the lower center are at least two more strings with slightly different size beads in each. Because of the fine lamination, the rock splits readily, and, to the far left, two smaller beads of another string are on a triangular-shaped slightly higher surface. Near the top of the slab, two more larger beads are on a slightly lower surface.

Specimens are vertically compressed so as to be nearly one dimensional, but sufficient detail is present to reconstruct the mature form of each "bead" as a low broad cone. The "beads" of *Horodyskia* are upwardly slightly curved plates of silica, this

Fig. 1. A relatively smooth upper bedding plane surface from the Appekunny Formation on which a one (1) cm scale has been placed. The holotype is above the scale. USNM 508100, from Running Wolf Mountain, Glacier National Park, Montana, USA (for locality details see Fedonkin et al. 1994, p. 206).

mineral having replaced the original material; the present composition was determined by an electron probe. On the bedding plane surfaces, the internal fillings of the cones stand up as low hemispheres. We estimate that these cones may have grown to a maximum height of about 1 cm during life, but were partially within the sediment throughout their growth. Repeated sectioning of specimens on both sole and bedding plane surfaces and examination under SEM did not produce any details on dimensional shape and mode of growth.

Three lines of evidence suggest the integument of the individual cones was relatively resistant during life. First, some were plucked from the sediment by current action, leaving triangular or quadrangular impressions (Fedonkin et al. 1994, fig. 21). Second, some show current crescents where moving water washed away fine-sized silt around part of the circumference and deposited slightly coarser silt in the depression. Third, some decayed in place and are surrounded by an irregular brown stain. Ancillary evidence that the cones had a thick, resistant wall is given by the absence of any wrinkling of the integument; this is marked contrast to specimens of the younger microfossil *Chuaria* Walcott, which are so wrinkled as to superficially resemble the texture of raisins.

An artistic rendering to show the life position and resistance of the beads is included (Fig. 2). A strong water current from the upper right has excavated current crescents

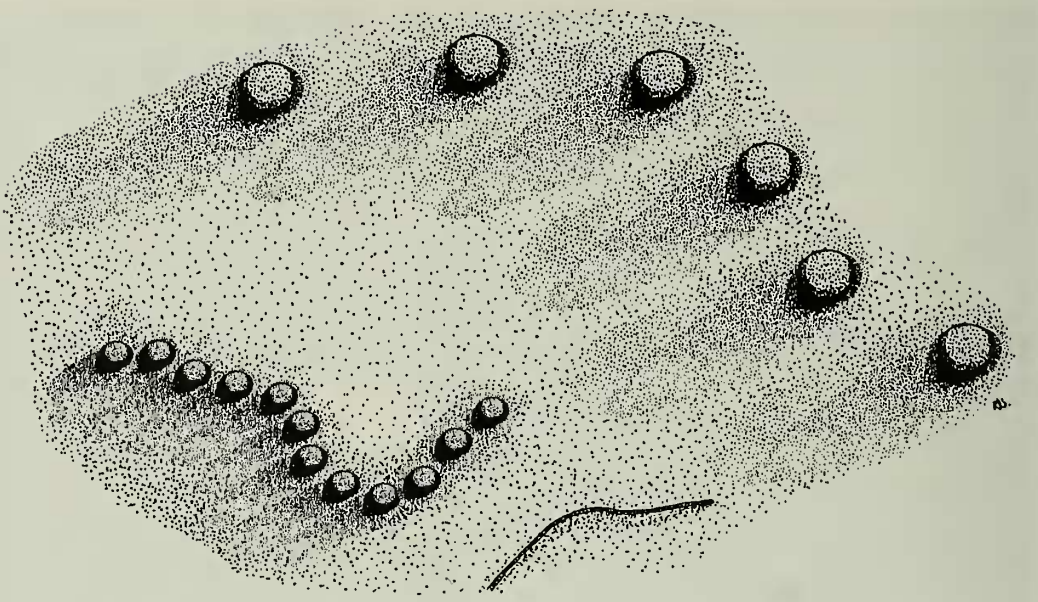

Fig. 2. Artistic rendition of two strings of beads standing in low relief above the bottom, with the sediment affected by their interruption of water movement from the upper right. A stolon which has not yet developed swellings as the first stage of upward growth is lying on the sediment at the lower edge of the drawing. Drawn at approximately natural size.

behind each of the beads of two strings and has left faint current shadows on the fine-grained silt sediment surface.

A few cones appear to have partially flaked away so that the interior may be observed. They may have had interior ridges or rods to strengthen the wall, but the evidence is still relatively inconclusive. Because most of the material is on loose slabs, and has been variously affected by taphonomic processes and subsequent weathering, interpretation of the material is complex and is continuing.

Discussion.—Even though many pseudofossils have been named from the Precambrian, the organic nature of these specimens is defendable. Several forms of traces and inorganic features occur in the Appekunny Formation (Fedonkin et al. 1994), but none of these resemble this material. No sedimentary processes are known which would produce these nearly uniformly spaced spots in elongate strings of varying direction.

On the other hand, the proportionality between the size of the spots and their spacing is remarkable and compelling. No matter how small or how large are these spots, the relative spacing is consistent within the limits of individual effects of preservation and biologic variability. As a general rule, small beads are nearly circular and the larger the beads on a string, the more irregularity there is among the beads. We attribute this irregularity to effects of water currents during life, differential compression and other taphonomic effects.

Many of the strings collected fall within a limited size range for the beads, but it is possible to suggest a gradual increase in spacing with increase in size. At the earliest stage of upward growth, spaces are about the same length as the diameter of the swellings. For the largest known individual the diameter of beads is just over 1 cm and the spacing is just under 2 cm. Organic growth is indicated as the most plausible mechanism to explain the near proportional uniformity of spacing.

Precise measurements are difficult because the boundaries of beads are not al-

ways easy to observe. The values given below are approximate, but are representative of the proportionality of bead size to spacing. The holotype (USNM 508100) has seven beads about 43 mm in diameter and spaced at about 53 mm intervals. For five paratypes the comparable figures are: USNM 508103, 21 beads, 39 mm in diameter and 42 mm spacing; USNM 508110, five beads, 49 mm, and 57 mm; USNM 508112, 22 beads, 27 mm, and 39 mm; USNM 508122, seven beads, 44 mm, and 71 mm; and USNM 508124, eight beads, 41 mm, and 42 mm.

Individual strings vary both in length and in direction, commonly being slightly curved or sigmoïdal. The strings show no preferred orientation on hummocky surfaces. On some strings more than 25 beads are present. Specimens on sole surfaces are more common, but this may be because they are easier to observe in the field. Even by the standard of Phanerozoic occurrences of fossils, at the three localities where *H. moniliformis* has been collected, specimens are abundant.

Horodyski published additional illustrations during a decade following his original work, but no more descriptive matter was added and he was never clear that these structures were indeed organic. All his illustrated specimens are from the lower (sole) surfaces of beds, not the bedding planes, as he wrote. No specimens branch, and there is only one form present, two other points in which we disagree with his original informal discussion. Several strings are illustrated in Fedonkin et al. (1994, figs. 20–23). We envision that episodically the growing colony was covered with a slightly thicker than average layer of dust settling through the water column. To insure that the smothered colony did not die, alternate cones presumably transferred part of their substance to adjacent cones, allowing them to grow upward through the sediment. When the next thicker layer settled, the transfer of material from intermediate cones was repeated. We can think of no other mechanism to explain the spacing of the cones. One factor stimulating cell redistribution and upward growth might be chemotactic attraction to the overlying oxidized environment.

If our interpretation of the growth pattern is correct, it implies a relatively high level of biological organization at a geologically early time. This is colonial growth, but it is unlike colonies which grow by the increase in size of individuals without adding new individuals. We are not aware of any living organisms which are closely comparable to *Horodiskia*.

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